Fruit Trees in a Malaysian Rain Forest[1]

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*An inventory was made of 50 ha of primary lowland rain forest in Peninsular Malaysia, in which ca. 340,000 trees 1 cm dbh or larger were measured and identified to species. Out of a total plot tree flora of 820 species, 76 species are known to bear edible fruit. Especially diverse were the wild species of mango (*Mangifera, *Anacardiaceae, 12 spp.), mangosteen (*Garcinia, *Clusiaceae, 13 spp.), breadfruit (*Artocarpus, *Moraceae, 10 spp.) and rambutan (*Nephelium, *Sapindaceae, 5 spp.). Median population size for all species of fruit trees was 3.0 trees per ha and 0.2 adult trees per ha. Direct economic value of wild fruit trees was small; only one species has been very much collected and sold,* Parkia speciosa *(Fabaceae), amounting to less than US$20 per ha per year. The potential value of the species as genetic resources is very large: 24 species are cultivated, 38 edible species are congeneric with cultivated crops and at least 10 other species bear inedible fruit but are related to cultivated crops. We conclude that the Peninsular Malaysian rain forest is exceedingly rich in wild fruit trees, that these normally live at low densities, and that their principal economic value is as genetic resources.*

Arboles frutales en una selva lluviosa de Malasia. *Se hizo un inventario de 50 ha. de tierra baja primaria de selva lluviosa de Malasia Peninsular, en el cual se medió y se identificó la especie de aproximadamente unos 340,000 árboles de 1 cm de diametro (a la altura del pecho) o mayores. De un total de un terreno de flora de árboles de 820 especies, se sabe que 76 especies dan frutos comestibles. Resultaron ser particularmente variades las especies silvestres de mango (*Mangifera, *Anacardiaceae, 12 spp.), mangostán (*Garcinia, *Clusiaceae, 13 spp.), arbol del pan (*Artocarpus, *Moraceae, 10 spp.) y rambután (*Nephelium, *Sapindaceae, 5 spp). El valor mediano del tamaño de la población de todas las especies de árboles frutales fue de 3.0 árboles por hectare y de 0.2 arboles adultos por hectare. El valor económico directo de los árboles frutales silvestres resultó pequeño; solamente una de las especies ha sido muy recogida y vendida,* Parkia speciosa *(Fabaceae), sumando menos de US$20 por hectare por año. El valor potencial de las especies como reserva genética es muy grande: 24 especies son cultivadas, 38 especies comestibles son congéneres de cosechas cultivadas y por los menos otras 10 especies dan frutos incomestibles pero están relacionadas con cosechas cultivadas. Concluimos que la selva lluviosa de la Peninsula de Malasia es extremadamente rica en árboles frutales silvestres, que éstos normalmente viven en bajas densidades y que su principal valor económico es como reserva genética.*

Pokok buah-buahan dalam hutan hujan di Malaysia. *Satu inventori telah dijalankan di satu kawasan hutan hujan tanah pamah seluas 50 ha di Semenanjung Malaysia. Daripada kerja-kerja inventori ini, sebanyak 340,000 pokok yang mempunyai pepepang 1 cm atau lebih telah diukur dan dicamkan hingga ke peringkat spesies. Sejumlah 820 spesies telah dikenalpasti dan daripada jumlah ini, sebanyak 76 spesies telah diketahui menghasilkan buah yang boleh dimakan. Kepelbagaian*

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*yang luas terdapat dalam spesies liar mangga (*Mangifera, *Anacardiaceae, 12 spp.), manggis (*Garcinia, *Clusiaceae, 13 spp.), sukun (*Artocarpus, *Moraceae, 10 spp.) dan rambutan (*Nephelium, *Sapindaceae, 5 spp). Median saiz populasi untuk semua spesies buah-buahan ialah 3.0 pokok setiap hektar dan bagi pokok buah-buahan yang matang pula ialah 0.2 pokok setiap hektar. Sumbangan ekonomi secara langsung dari buah-buahan liar ini adalah kecil; hanya satu spesies sahaja iaitu* Parkia speciosa *(Fabaceae) yang biasa dikutip dan dijual dengan harga kurang dari US$20 setiap hektar setiap tahun. Spesies-spesies yang berpotensi sebagai sumber-sumber genetik adalah banyak; 24 spesies yang ditanam, 38 spesies yang boleh dimakan tergolong dalam genus yang sama (kongenerik) dengan spesies yang ditanam, dan sekurang-kurangnya 10 spesies lagi yang tidak boleh dimakan tetapi mempunyai pertalian dengan spesies tanaman. Daripada inventori ini, boleh disimpulkan bahawa hutan hujan Semenanjung Malaysia sangat kaya dengan spesies buah-buahan liar dan biasanya terdapat dalam kepadatan yang rendah, tetapi nilai ekonomi asas daripada spesies-species liar ini ialah sebagai sumber-sumber genetic.*

The continuing worldwide loss of primary rain forest requires a prompt economic analysis of the remaining forest reserves. A special emphasis should be placed upon non-timber products, because their nature and value are poorly known relative to timber. (Non-timber resources of Southeast Asia were recently reviewed in de Beer and McDermott 1989, Mehra and Sastrapadja 1985, and Siemononsma and Wulijarni-Soetjipto 1989.)

In Malaysia, edible fruits and nuts borne by wild forest trees contribute economic value to the forest by virtue of their use in indigenous and immigrant cultures, and by their taxonomic proximity to cultivated species (Burkill 1935; Corner 1988; Lemmens et al. 1989; Meijer 1969; Voon et al. 1988). To assess their existing and potential economic value we need well documented ethnobotanical observations, but also we need quantitative data on the diversity and abundance of the species.

Reports on the composition of primary forest indicate that edible fruit trees are of moderate diversity, 10 to 20 species in a site, and of generally low abundance, 1 to 5 trees per hectare (Abdul Manap 1979; Hashim 1986; Ho 1971; Jong et al. 1973; Poore 1968; Soepadmo 1979; Whitmore 1971; Wyatt-Smith 1966). These reports are based on forest inventory plots of 1 or 2 ha in which trees are enumerated only if they exceed 10 cm dbh or, for some plots, 30 cm dbh, thereby missing many smaller species and neglecting a more complete view of population structure.

To evaluate the diversity and abundance of fruit trees more comprehensively, we examined data from a 50-ha plot in a primary rain forest in which all trees 1 cm in diameter or more were measured and identified. The data are summarized with four questions in mind: What species of trees bearing edible fruits are found in the plot? What does the population structure indicate about the likely conservation of these populations? What contribution to the local economy is made by wild-gathered fruits? What are the likely genetic resources as evidenced by taxonomic relationships?

SITE DESCRIPTION AND METHODS

The Forest Research Institute of Malaysia (FRIM) initiated a 50-ha permanent plot in 1985 at Pasoh Forest Reserve, Negeri Sembilan, to study the population

biology of trees in a primary forest. Details of the plot survey methods, logistics of the enumeration, and methods of measuring and identifying trees are described in Manokaran et al. (1990).

The site is located at 2°55′N latitude and 102°18′W longitude, or about 140 km southeast of Kuala Lumpur. The reserve includes about 6000 ha of forest, of which the southernmost 2000 ha are administered by FRIM as a Research Center. This area is divided into three portions: a core of 650 ha of primary lowland forest; a buffer zone of 30-yr-old selectively logged forest bounding the core on three sides; and primary hill forest on the fourth side. The buffer zone is bounded in turn by extensive plantations of oil palm (*Elaeis guineensis* Jacq.) established between 1972 and 1974.

The vegetation is mixed dipterocarp rain forest, the last remnant of the lowland forest that once covered more than 100,000 ha of the south-central Malaysian Peninsula. The mean annual rainfall is only 2000 mm, which is very dry for the peninsula, but the forest is nonetheless exceedingly diverse, with more than 800 species of trees and shrubs recorded in the 50-ha plot (Kochummen et al., n.d.). The avifauna includes about 200 breeding species and about 40 migrant species (D. Wells, pers. comm.), whereas mammal species number roughly 90 (Kempler 1988).

Species of trees were identified in accordance with the taxonomy and nomenclature of the *Tree Flora of Malaya* (Ng 1978, 1989; Whitmore 1972a), except when a more recent revision may have appeared. Identifications were documented through collection of roughly 3000 herbarium specimens that include either flower or fruit, and through another 4000 specimens of sterile material. The relevant specimens are cited after each name and stored as a permanent voucher collection in the herbarium of the Forest Research Institute of Malaysia (KEP). A complete list of species found in the 50-ha plot can be found together with citations of voucher specimens in Manokaran et al. (1990).

In general, we cite a species as edible only if we ourselves have tried it, or if it has been eaten by our informants, or in such cases as the rarely fruiting mangoes, if it can be safely assumed to be edible. The edibility of certain wild fruits is, of course, open to some question and controversy, so some of the species listed by Burkill (1935) or Lemmens et al. (1989) do not appear in our list, even though the species were in the plot. In some cases we excluded a species if we had doubts concerning its toxicity, or if it had very small and near fleshless fruit. Most of the doubtful species are mentioned in the results or discussion.

The descriptions in the Appendix were prepared as uniformly as possible to facilitate comparison. For each species we list first the name, taxonomic authority, voucher specimen, and vernacular Malaysian name. (The vernacular name is that which is commonly used by the staff at FRIM and may differ from names used in some provinces of Peninsular Malaysia.) Description of the fruit follows, based whenever possible on plants from Pasoh, but for a few species it was necessary to use comparable specimens from elsewhere in Peninsular Malaysia. Details of flavor and texture, whenever given, are based on the species as they occur at Pasoh. Species are not known to be cultivated unless so indicated; likewise, species are not gathered regularly at Pasoh unless so indicated.

The population structure of each species was tallied by aggregating trees into convenient diameter classes and then describing the number of trees larger than

1, 10, 20, and 30 cm dbh. The dbh data are from the original census of the 50-ha plot, ending November 1988.

The adult size was defined for each species as that size at which an individual in the forest might be expected to flower and was necessarily based on field experience. Trees at smaller diameters might bloom under cultivation or in logged forests.

RESULTS

Floristic diversity

Out of a total tree flora of roughly 820 species, 76 bear edible fruits, or roughly 9% of the flora. These species represent 26 genera and 15 families.

Five genera in five different families make up more than half the fruit tree flora, and four of these are related to important cultivated crops. The wild mangoes, *Mangifera* (Anacardiaceae), were represented by 12 species including all 10 species that might reasonably be found in lowland forest of central Malaya, together with two species that were new records for the peninsula. The species of wild mangosteen, *Garcinia* (Clusiaceae), numbered 13, which is about one-fourth of the 49 species known for the peninsula; two undescribed species are included. The wild rambutans, *Nephelium* (Sapindaceae), numbered 5; the forest breadfruits, *Artocarpus* (Moraceae), 10. Additionally, there were 6 species of *Baccaurea* (Euphorbiaceae).

Several families important in the Pasoh tree flora are conspicuously absent from the list. The Dipterocarpaceae is the dominant family among upper canopy trees, but none produces edible fruit. The genus *Diospyros* (Ebenaceae) is represented by over 20 species at Pasoh, but none is known to produce edible fruit that can compare with *D. kaki* L.f., or *D. virginiana* L., and some of the forest species are very poisonous. We cite no species of Sapotaceae as edible, and in this we may be mistaken, for Burkill (1935) considered our common *Palaquium hexandrum* (Griff.) Baill. as having a sour, edible fruit and fatty seed. However, we did not find this small fruit at all inviting, and our aboriginal informants did not consider it edible. The family Annonaceae, represented by more than 50 species in the 50-ha plot but not at all in the list of edible fruits, may also be mistakenly overlooked. Likewise, the many species of Myristicaceae may include some edible fruits. For example, the bright ruby red aril of *Knema pseudolaurina* de Wilde was, on one tasting, sweet and pleasantly spicy, and some species of *Horsfieldia* have fruit walls that are very thick and juicy. But our informants among the aborigines do not know them to be edible, and we omit them for ignorance of their possible toxicity.

As mentioned in the methods, we have also omitted from our enumeration some trees and shrubs that appear on lists such as Lemmens et al. (1989), even though some are very numerous in the plot, because our experience was that the fruit were exceedingly small and fleshless, or did not otherwise reflect a level of edibility comparable to the other species. These include *Rinorea sclerocarpa* (Bugersd.) Jacobs, *Anacolosa frutescens* (Bl.) Bl., *Antidesma tomentosa* Bl., *Cheilosa malayana* (Hk.f.) Airy Shaw, *Diospyros diepenhorstii* Miq., *Eugenia scortechinii* King, *Pimelodendron griffithianum* (Muell. Arg.) Benth., *Ficus* spp., *Lepisanthes fruticosa* (Roxb.) Leenh., and *Lithocarpus wallichianus* (Hanes) Rehd. Other ex-

amples of marginally edible fruits are four species of *Canarium* (Burseraceae) that have edible mesocarps or seeds, much inferior to those of *C. megalanthum* Merr., which itself is inferior to the valuable Kenari nut tree, *C. indica* L. As another example, there are eight species of *Dacryodes* (Burseraceae) that may also have a more or less edible mesocarp but are only rarely eaten, if at all, by aboriginal people. Altogether, these lesser fruits and yet undiscovered fruits might add another 50 species of trees to the total.

The types of fruit represented among the species are, not surprisingly, quite diverse in morphological detail, but five general habits are evident. Twenty-two species share the overall aspect of mango, a drupe with a fleshy mesocarp. Twenty-seven species share the overall aspect of either a rambutan or mangosteen, a dry-walled berry with a fleshy pulp or jacket about the seed or seeds. Seventeen species share a more or less creamy aril as their main attraction, though the outward appearance of the fruits varies greatly. Eight species have nuts, including two species of *Scaphium* (Sterculiaceae) that are used to make a mucilaginous drink. Finally, two species of legumes have large bean pods, from which the seeds and their dry arillate coverings are eaten.

Population structure

Our second question about wild species of fruit trees concerned their population size and structure (Table 1). The species with the highest density was *Xerospermum noronhianum* Bl. (Sapindaceae), which is also the most common tree in the plot; its density was 180 trees per ha. Several species were known from only a few trees. Among these was *Garcinia prainiana* King, known from only one tree, and an unidentified species of mango, *Mangifera* species 2, that was represented by only two large trees.

The median population size per species is 153 trees 1 cm dbh or larger in 50 ha, or roughly 3 trees per hectare. Forty-one species have densities between 1 and 10 trees per hectare, 19 species are more dense, and 17 species are less dense. The 90th percentile falls at 26 trees per hectare; only 7 species have a higher density.

The number of estimated adult trees follows a similar pattern. The median population is 10 adults per 50 ha. Again, 40 species have adult densities of 0.1 to 1 adult tree per hectare, whereas 19 species have higher densities and 17 species have lower densities. The 90th percentile falls at 3.2 adult trees per hectare; only 7 trees have a higher density.

Although adult populations appear to be generally low, and despite the infrequency with which some species are known to fruit (Yap 1982), we nonetheless find a high level of representation among trees in lower dbh classes, which may indicate that most species are regularly reproducing.

Many relatives of cultivated crops appear with very low densities. The genus *Mangifera* exhibits uniformly low density among its many species. Taken as a whole, the genus is represented by only 0.1 adults per hectare. The genus *Artocarpus* is also represented by species of low density, 0.39 adults per hectare, although we might note that, unlike the mangoes, *Artocarpus* includes several species much more common in secondary forests and roadsides than in primary forest.

Table 1. Frequency of fruit trees in 50-ha plot at Pasoh Forest Reserve, Malaysia, according to diameter at breast height. Adult size is an estimate of minimum diameter attained before flowering. Frequency in each column indicates the number of stems greater than or equal to different diameter classes in 50 ha. Authorship and voucher specimens for each species are provided in Appendix

Family /Species	Estimated adult size (cm dbh)	Number of adults	Number of trees in 50 ha with a diameter (cm) ≥			
			1	10	20	30
ANACARDIACEAE:						
Bouea macrophylla	10	52	525	52	16	5
Bouea oppositifolia	10	37	295	37	4	0
Dracontomelon dao	20	2	39	5	2	0
Mangifera foetida	20	4	204	14	4	1
Mangifera gracilipes	20	7	124	20	7	2
Mangifera griffithii	20	16	133	48	16	3
Mangifera indica	20	2	76	11	2	0
Mangifera lagenifera	20	8	26	11	8	5
Mangifera macrocarpa	20	2	50	5	2	2
Mangifera magnifica	20	7	122	10	7	1
Mangifera sp. nov. 3	30	2	12	5	2	2
Mangifera sp. nov. 1	30	5	73	12	7	5
Mangifera sp. nov. 2	30	1	2	2	1	1
Mangifera quadrifida	15	7	351	11	5	3
Mangifera superba	30	2	86	28	7	2
BOMBACACEAE:						
Durio oxleyanus	20	10	89	16	10	6
BURSERACEAE:						
Canarium megalanthum	30	5	199	26	11	5
Canarium littorale	20	100	3304	343	100	44
Dacryodes rugosa	15	133	5569	521	91	5
CLUSIACEAE:						
Garcinia atroviridis	10	1	6	1	0	0
Garcinia bancana	10	21	155	21	2	1
Garcinia eugeniaefolia	4	108	717	4	0	0
Garcinia forbesii	5	5	35	1	0	0
Garcinia griffithii	10	0	30	0	0	0
Garcinia malaccensis	5	105	1024	2	0	0
Garcinia nervosa	10	23	538	23	9	3
Garcinia nigrolineata	10	5	391	5	0	0
Garcinia parvifolia	10	43	557	43	8	2
Garcinia prainiana	10	0	1	0	0	0
Garcinia rostrata	10	6	92	6	0	0
Garcinia sp. nov. 1	15	5	65	10	2	0
Garcinia sp. nov. 2	20	3	58	5	3	1
EUPHORBIACEAE:						
Baccaurea griffithii	10	8	88	8	1	0
Baccaurea minor	10	11	81	11	4	2
Baccaurea parviflora	1	3474	3474	18	0	0
Baccaurea pyriformis	10	8	47	8	1	0
Baccaurea racemosa	4	432	1242	122	3	0
Baccaurea reticulata	20	42	423	91	42	17
Elateriospermum tapos	20	41	220	63	41	25
Phyllanthus emblica	20	3	10	3	3	1
FABACEAE:						
Archidendron bubalinum	10	193	1981	193	32	4

Table 1. Continued.

Family /Species	Estimated adult size (cm dbh)	Number of adults	Number of trees in 50 ha with a diameter (cm) ≥			
			1	10	20	30
Dialium maingayi	20	8	65	9	8	2
Dialium platysepalum	20	46	1113	96	46	26
Dialium procerum	20	24	131	49	24	12
Dialium wallichii	20	9	44	11	9	7
Parkia speciosa	20	42	528	80	42	31
FAGACEAE:						
Castanopsis inermis	20	5	38	8	5	4
Castanopsis megacarpa	20	9	100	16	9	3
Castanopsis schefferiana	30	52	558	131	52	40
FLACOURTIACEAE:						
Flacourtia rukam	1	151	151	1	0	0
GNETACEAE:						
Gnetum gnemon	1	580	580	0	0	0
MELIACEAE:						
Lansium domesticum	10	160	1545	92	28	5
Reinwardtiodendron cinereum	6	63	721	31	2	-
Sandoricum koetjape	20	3	125	25	3	0
MORACEAE:						
Artocarpus anisophyllus	20	3	24	14	3	3
Artocarpus dadah	20	6	148	18	6	2
Artocarpus elasticus	20	0	69	6	0	0
Artocarpus fulvicortex	20	6	153	15	6	2
Artocarpus integer	10	59	309	59	21	5
Artocarpus lowii	20	20	189	43	20	12
Artocarpus maingayi	20	12	111	38	12	9
Artocarpus nitidus	10	33	498	33	9	4
Artocarpus rigidus	20	22	214	47	22	17
Artocarpus scortechinii	20	33	279	70	33	25
OXALIDACEAE:						
Sarcotheca griffithii	20	56	210	74	56	39
POLYGALACEAE:						
Xanthophyllum amoenum	10	7	398	7	4	1
Xanthophyllum stipitatum	10	7	112	13	7	6
SAPINDACEAE:						
Nephelium costatum	10	164	1495	164	57	14
Nephelium cuspidatum var. *eriopetalum*	10	27	226	27	9	1
Nephelium cuspidatum var. *ophiodes*	10	30	214	30	6	1
Nephelium hamulatum	10	1	3	1	0	0
Nephelium lappaceum var. *pallens*	10	1	13	1	0	0
Nephelium maingayi	10	55	297	55	25	6
Pometia pinnata	10	169	633	169	82	35
Xerospermum noronhianum	10	564	8968	564	161	4
STERCULIACEAE:						
Scaphium linearicarpum	20	19	135	37	19	10
Scaphium macropodum	20	82	785	221	82	68

Direct economic value

Our third question concerned the extent to which fruits are gathered from Pasoh by local residents, either for personal use or for sale. We found that only one species was routinely gathered for sale, *Parkia speciosa* Hassk. (Fabaceae). This species flowers more or less annually, though not in tight synchrony, so some fruit are usually available intermittently throughout the year. The very largest trees may produce as many as 500–1000 fruits in a good year. These are usually collected by aborigines who must first climb the tree, then use a long, hooked pole to gather the clusters of pods. The price a pod will fetch varies on its quality, especially upon the maturity of the seeds, and averages about 1 ringgit (US$0.37). Thus, even the largest trees in the best of years would not provide an income much beyond US$370, and at Pasoh these big trees are rather scarce, with densities of one tree per 10–20 ha. Smaller adults occur at densities of about one tree per hectare, but would not set much more than 50 or so fruits per tree. The total annual contribution of *P. speciosa* to the local economy does not exceed US$20 per hectare.

We also found that 14 other species are routinely sought out for personal consumption, but they are available only intermittently, and are rarely if ever sold, and so do not play a substantial role in the local fruit market. This is not to say they are not exploited elsewhere in Malaysia. The tampoi, *Baccaurea reticulata* Hk.f. (Euphorbiaceae), is extensively gathered and sold along the roadsides in the states of Pahang, Kelantan, and Trengganu, but evidently it is not sufficiently common at Pasoh to be exploited. The remaining 61 species of edible fruits in our enumeration are not routinely or actively sought and so have no direct economic value.

Genetic resources

The fourth question that we posed concerned the value of the fruit trees as genetic resources. This term usually has two practical applications (Anonymous 1986). On the one hand, wild species might be newly recruited for cultivation; on the other hand, wild species may be used to improve existing cultivars through techniques such as grafting, hybridization, or tissue culture.

With regard to the cultivation of wild trees, we find that 24 of the 76 species of wild fruit trees in our enumeration are currently cultivated in the Malay Archipelago. Of the remaining 52 species, several may merit the attention of horticulturists because they could possibly be improved to a marketable fruit. Among these we could mention *Xerospermum noronhianum, Baccaurea reticulata,* and most species of *Garcinia.* It must be added that while each of these species exhibits desirable qualities, they would nonetheless require significant improvement through breeding and selection. As such, we find no evidence for the notion that entirely novel fruit trees of immediately marketable quality can be found in the rain forest.

A second application of wild fruit trees as a genetic resource is as a means of improving existing cultivars. In this regard, the edible fruit trees at Pasoh can be tallied into two categories based on taxonomic proximity to cultivated species: 24 species are wild conspecific relatives of cultivated crops, and 37 others are not themselves cultivated, but are congeneric with cultivated species. Thus, within the 50-ha plot we find a total of 61 tree species with edible fruits that are potentially useful in improving species already under cultivation.

To this total we might add another category that would include those species that do not bear edible fruits themselves, but are related to species that do. Some examples in this category are two species of *Prunus* (Rosaceae), two of *Durio* (Bombacaceae), three of *Castanopsis* (Fagaceae), and more than 40 of *Eugenia* (Myrtaceae). A common use of species such as these is as rootstocks upon which quality species can be grafted. For example, at least one species common at Pasoh, *Eugenia densiflora* (Bl.) Miq., has already been used in this fashion in Java for growing the common jambu, *E. jambos* L. (Argles 1976). Those interested in a full enumeration of plants in this category might consult the complete species list for the 50-ha plot in Manokaran et al. (1990).

DISCUSSION

Our results substantiate the opinion that the Malaysian rain forest is one of the world's principal resources for fruit trees. More importantly, we found that the fruit tree flora is well represented in patches of forest no larger in size than 50 ha.

The number of cultivated species represented in the wild (24) and the portion of the tree flora that bears edible fruits (9%) is evidently quite high when compared to what is known for other parts of the world. For example, a 1-ha sample of very rich forest in Peru, known for its high diversity of edible fruits, revealed about 300 species of trees over 10 cm dbh, but only 11 species with edible fruits (A. Gentry, pers. comm.)

We do not know how far our results might apply to the rest of Peninsular Malaysia, but it seems likely that the results from Pasoh are typical of the lowland forest that once covered the region. Even the more remarkable features of the flora, such as the very high representation among species of mangoes, may be duplicated in other locations (Bompard and Kostermann 1985). Insofar as the floristic composition of Pasoh is characteristic of the region (Kochummen et al., in press) we can consider the results of the fruit tree enumeration to be of general applicability.

The population data indicate a clear potential for local extinction. When densities of 0.1 to 1 adult tree per hectare are multiplied by the 600 ha of primary forest in Pasoh, the total adult population of 60 to 600 trees seems dangerously low. But to realistically estimate just how stable or unstable these population densities are, we need to know much more about the species-specific factors that control stability and change in natural populations.

Nonetheless, our results do allow us to develop a perspective on conservation in a slightly different way. If we want populations of 1000 adults for most species of wild fruit trees, and if densities are roughly uniform above the scale of 50 ha, then we must preserve forest tracts in the vicinity of 5000 ha. For the more scarce species, such as the wild mangoes, which have densities on the order of 0.1 adult trees per hectare, we would need 10,000 ha to capture a population of 1000 adult trees. Tracts of primary forest of this size in Peninsula Malaysia are now found only in Endau-Rompin Park and the National Park (Taman Negara).

There are two things we would need to know to better interpret our data in light of conservation goals. What are the regional distribution patterns of the edible fruit trees? How does selective logging modify the density and diversity of the fruit tree flora? The answer to these questions would allow us to better evaluate the value of primary versus secondary forest in conserving wild fruit species.

With regard to our third question, the results indicate that wild fruit trees directly contribute very little to the local economy. It has become commonplace to suggest that the sale of wild fruit crops and other non-timber products could offer a non-destructive means of exploiting forest resources to the benefit of a local community and in contrast to conventional logging practice (e.g., de Beer and McDermott 1989). We can contribute no evidence to support that notion. The remaining 600 ha of primary forest in Pasoh Forest Reserve should certainly be conserved, but the argument that its preservation can be justified through the direct contribution provided by non-timber products to the local economy should be examined quantitatively and reviewed with caution.

The results indicate that a much greater economic value lies in the potential for either developing new commercial crops or improving species already under cultivation. Of course, developing novel crops is subject to great uncertainty, and in any case would first require selection and improvement. The fruit of tampoi, *Baccaurea reticulata,* is quite palatable but the tree requires many years to reach adult size. The same might be said for the wild chestnuts of the genus *Castanopsis.* The fruits of wild *Garcinia* spp. are rather small and produced infrequently. Slow growth and infrequent fruiting are only two features that would retard the speedy commercialization of wild fruits.

The greatest significance of the wild fruit trees at Pasoh is their taxonomic proximity to cultivated crops. Of particular economic importance are the wild relatives of species already in cultivation. At Pasoh, 24 such species were documented, and these wild trees could be of use to plant breeders looking for ways to improve existing cultivars. In general, the wild trees are inferior to their cultivated relatives in many important commercial qualities such as thickness of edible matter, or its sweetness. But, of course, they very likely possess other traits that may be of value, such as disease resistance.

The use of wild trees in plant improvement is necessarily complicated by uncertainties regarding the biology and taxonomic relationships among the species; a few examples can illustrate the range of problems and possibilities that each crop presents.

In recent years the petai tree, *Parkia speciosa,* has been successfully propagated from cuttings of adult trees. These cuttings bloom and set fruit after only a few years and thereby provide the means for cross breeding, selection of preferred clones, and the rapid commercialization of what had formerly been a wild-gathered fruit.

A peculiarity of the most popular cultivated mangosteen, *Garcinia mangostana* L., may make the wild species of *Garcinia* particularly important in tree improvement and breeding programs. Like all species of *Garcinia, G. mangostana* is dioecious, but its staminate tree has never been found and its propagation is solely through apomictically derived seeds. The nearest relative of the mangosteen is thought to be either *G. malaccensis* Hk.f., which is at Pasoh, or *G. hombraniana* Pierre, which is found in the hills; either of these may possibly provide a means of hybridization. The other species may provide stock for grafting.

Wild mangoes present a promising array of species for crop improvement. Many species bear fruits of good quality and exhibit a range of ecological attributes that may be of use to plant breeders; but the biology of wild mangoes remains largely unknown. The flowers and fruits of several species have never been described. It is not surprising then that the taxonomic relationships among cultivated and wild

species are controversial. Kochummen (1989) wrote that *Mangifera indica* L., the mango of plantations, could be found in the wild as far east as the Malay Peninsula, including Pasoh Forest. This opinion is not shared by other specialists such as J. Bompard and A.J. Kostermann (unpubl. report) who contend that the forest trees at Pasoh should be called *M. laurina* Bl., and that wild *M. indica* is restricted to India. Hou (1978) also wrote that *M. indica* was restricted to India, but claimed that *M. laurina* was a synonym of *M. indica,* and that the wild forest trees of Malaya were *M. longipes* Griff. The two other cultivated species, *M. foetida* Lour. and *M. odorata* Griff., are also problematic. Hou (1978) asserted that the latter was a hybrid between the former and *M. indica,* an opinion that has not met with wide agreement.

These examples highlight the need for continuing basic research on the relatives of cultivated fruit trees. Specialized studies on crop silviculture and orchard management should be balanced with broader research on the taxonomy and autecology of related forest species.

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LITERATURE CITED

Abdul Manap, A. 1979. Genetic resources of tropical forest trees—conservation options. Malayan Nat. J. 33:25–38.

Anonymous. 1986. Genetic resources of tropical and sub-tropical fruits and nuts (excluding *Musa*). International Board for Plant Genetic Resources, Rome.

Argles, G. K. 1976. *Eugenia.* Pages 334–375 *in* R. J. Garner and S. A. Chaudhri, eds., The propagation of tropical fruit trees. Horticultural Review Number 4, Commonwealth Agricultural Bureau, Kent, UK.

Bompard, J. M., and A. J. Kostermann. 1985. Wild *Mangifera* species in Kalimantan, Indonesia. Pages 172–174 *in* K. L. Mehra and S. Sastrapadja, eds., Proceedings of the international symposium on South-East Asian plant genetic resources. National Biological Institute, Bogor, Indonesia.

Burkill, I. H. 1935. A dictionary of the economic products of the Malay Peninsula. Crown Agents for the Colonies, London.

Corner, E. J. H. 1988. Wayside trees of Malaya. 3rd ed. Malayan Nature Society, Kuala Lumpur, Malaysia.

de Beer, J. H., and M. J. McDermott. 1989. The economic value of non-timber forest products in Southeast Asia. Netherlands Committee for IUCN, Amsterdam.

Hashim, M. N. 1986. Wild fruit tree species: A lesser-known and under-utilized forest resource. Pages 154–169 *in* Y. K. Chan, P. Raveendranathan, and M. Zabedah, eds., Proceedings of the national fruit symposium, Malaysian Agriculture Research and Development Institute, Serdang, Malaysia.

Ho, C. C. 1971. The importance of Taman Negara as a gene pool of major cultivated plants. Malaysian Nat. J. 24:215–221.

Hou, D. 1978. Anacardiaceae. Flora Malesiana 8(3):395–548.

Jong, K., B. C. Stone, and E. Soepadmo. 1973. Malaysian tropical forest: An underexploited genetic reservoir of edible-fruit tree species. Pages 113–121 *in* E. Soepadmo and K. G. Singh, eds., Proceedings of the symposium on biological resources and national development. Malay Nature Society, Kuala Lumpur.

Kempler, C. 1988. The mammals of Pasoh Forest Reserve, Peninsular Malaysia. Malayan Nat. J. 42:1–20.

Kochummen, K. M. 1989. Anacardiaceae. Pages 9–57 *in* F. S. P. Ng, ed., Tree flora of Malaya. Vol. 4. Longmans, London.

———, J. V. LaFrankie, and N. Manokaran. n.d. Floristic composition of Pasoh Forest Reserve, Peninsular Malaysia. J. Trop. Forest Sci. (in press).

Lemmens, R. H., P. C. Jansen, J. S. Siemononsma, and F. M. Statvast, eds. 1989. Plant resources of South-East Asia: Basic list of species and commodity groupings (Version 1). Pudoc, Wageningen, Netherlands.

Manokaran, N., J. V. LaFrankie, K. M. Kochummen, E. S. Quah, J. Klahn, P. S. Ashton, and S. P. Hubbell. 1990. Methodology for the 50-ha research plot at Pasoh Forest Reserve. Research Pamphlet No. 102, Forest Research Institute of Malaysia, Kepong.

Mehra, K. L., and S. Sastrapadja, eds. 1985. Proceedings of the international symposium on South-East Asian plant genetic resources. National Biological Institute, Bogor, Indonesia.

Meijer, W. 1969. Fruit trees in Sabah (North Borneo). Malayan Forester 32(3):252–265.

Ng, F. S. P., ed. 1978. Tree flora of Malaya. Vol. 3. Longman, London.

———, ed. 1989. Tree flora of Malaya. Vol. 4. Longman, London.

Poore, M. E. D. 1968. Studies in Malaysian rain forest. 1. The forest on triassic sediments in Jenka Forest Reserve. J. Ecol. 56:143–196.

Siemononsma, J. S., and N. Wulijarni-Soetjipto, eds. 1989. Plant resources of South-East Asia: Proceedings of the first PROSEA international symposium. Pudoc, Wageningen, Netherlands.

Soepadmo, E. 1979. Genetic resources of Malaysian fruit trees. Malaysian Appl. Biol. 8(1):33–42.

Voon, B. H., P. Sim, and T. H. Chin. 1988. Sayur-sayuran dan buah-buahan hutan di Sarawak (Forest vegetables and fruits of Sarawak). Department of Agriculture, Sarawak.

Whitmore, T. C. 1971. Wild fruit trees and some trees of pharmacological potential in the forest of Ulu Kelantan. Malayan Nat. J. 24:222–224.

———, ed. 1972a. Tree flora of Malaya. Vols. 1 and 2. Longman, London.

———. 1972b. Guttiferae. Pages 162–236 *in* T. C. Whitmore, ed., Tree flora of Malaya. Vol. 2. Longman, London.

Wyatt-Smith, J. 1966. Ecological studies on Malayan forests. Research Pamphlet No. 52. Forest Research Institute of Malaysia, Kepong, Malaysia.

Yap, S. K. 1982. The phenology of some fruit tree species in a lowland forest. Malaysian Forester 45:21–35.

APPENDIX

Trees bearing edible fruits found within the 50-ha plot at Pasoh Forest Reserve, Malaysia

Anacardiaceae

In all species the fruit is a fleshy drupe with an edible mesocarp and inedible husk and seed.

Bouea macrophylla Griff. / [*FRI 37278*] / **kundang, kundangan,** or **setar** / Fruit ellipsoid, 3.5–5 cm long, ripening yellow or orange; mesocarp yellow, somewhat fibrous, sour, mango flavor. Trees with very sweet fruits are cultivated in villages; wild fruits are regularly gathered.

Bouea oppositifolia (Roxb.) Meisn. / [*LaFrankie 3311*] / **rumenia, rumia,** or **gemia** / Fruit broadly ellipsoid, 2.5 × 1.5 cm, ripening yellow; mesocarp yellow, fibrous, sour. Rarely cultivated; wild fruits collected.

Dracontomelon dao (Blanco) Merr. & Rolfe / [*LaFrankie 2768*] / **sengkuang** / Fruit globose, 2.5–3.8 cm, green ripening yellow; mesocarp, yellow, pulpy, sharply acidic, but sweet. Sometimes cultivated in villages.

Mangifera foetida Lour. / [*LaFrankie 4529*] / **bachang** / Fruit globose, 7.5–10 cm across, ripening green; mesocarp yellow, fibrous to very fibrous, sour with smell of turpentine. Wild fruit gathered for pickling; commonly cultivated in village orchards.

Mangifera gracilipes Hk. f. / [*PFR 1327*] / Fruit obliquely ellipsoid, about 5 cm × 3 cm, ripening pale yellow; mesocarp, pale, fibrous, sour.

Mangifera griffithii Hk. f. / [*PFR 1333*] / **rawa** / Fruit ellipsoid or obovoid, 2.5–3.5 cm × 2–2.5 cm, ripening pale yellow, according to Corner (1988) turning rose red and finally black; mesocarp pale orange-yellow, fibrous, watery sour. Sometimes cultivated in villages.

Mangifera indica L. / [*LaFrankie 3323*] / **pauh, mempelam, mangga** / Fruit oval to kidney-shaped, about 3.5–4.5 cm long, yellow-green; mesocarp pale yellow, thin, sour. Cultivated in plantations throughout the world (but see discussion of taxonomy in text); wild fruit regularly collected.

Mangifera lagenifera Griff. / [*PFR 1322*] / **lanjut** / According to Corner (1988), fruit pyriform, 10–15 cm long, pale dull green or greyish turning brownish; mesocarp dirty white to dirty pink, sour and fibrous. Occasionally cultivated.

Mangifera macrocarpa Bl. / [*PFR 1280*] / According to Hou (1978), fruit broadly oblong-globose, 8–12 cm long; mesocarp yellow, fibrous.

Mangifera magnifica Kochummen / [*PFR 1334*] / Fruit oblong, about 10 cm diam., yellow-green; mesocarp white, soft, fiberless, flavor not known. Not cultivated in Malaysia, sparsely cultivated in Sumatra.

Mangifera quadrifida Jack / [*LaFrankie 2866*] / **sepam, asam kumbang** / Fruit broadly ellipsoid, 8–10 cm × 5.5–7 cm, green flushed with dark purple; mesocarp light yellow, fibrous, sweet but sharply sour. Sometimes cultivated in villages. This variety is *quadrifida*; the variety *longipetiolata* (King) Kochummen is also found in the plot.

Mangifera superba Hk. f. / [*PFR 1295*] / **binjai** / According to Hou (1978), fruit obovate-oblong, when dried 10–15 cm × 7.5–9 cm; mesocarp greyish white or pinkish with unpleasant rotten smell. Cultivated more commonly in former times.

Mangifera sp. nov. 1 / [*PFR 1313*] / Flowers and fruits of this species are not known, but the leaves and twigs are distinctive. It was described as *Mangifera* sp. A in Kochummen (1989).

Mangifera sp. nov. 2 / [*PFR 1328*] / This species is known only from two large trees in Pasoh, and it may be *M. swintonioides*. Fertile material is not known.

Mangifera sp. nov. 3 / [*PFR 3887*] / This species has not been formally named. Although it has been known in Sumatra for quite some time, these are the first collections from the Malay Peninsula.

BOMBACACEAE

Durio oxleyanus Griff. / [*LaFrankie 4118*] / **durian beludu** / Fruit a woody capsule, spiny, globular, 15–21 cm across, greyish green; aril usually very thin, pale yellow, very sweet, pungent, but variable in flavor.

BURSERACEAE

Canarium megalanthum Merr. / [*LaFrankie2371*] / kedondong keruing / Fruit a drupe, ellipsoid, 5–6 cm × 3.3–4.5 cm, orange-yellow, scruffy ferruginous; mesocarp 1 cm thick, yellow, fibrous, odor

and flavor of mango but unpleasant on account of the sticky white exudate. Seed bluntly triangular, edible cotyledon palmately lobed, white, crisp. In Brunei, cultivated for its edible seeds, which are among the largest in this genus.

Dacryodes rostrata (Bl.) Lam. / [*LaFrankie 2379*] / **kedondong kerut** / Fruit a drupe, ovoid to oblong, 1.3–2.6 cm × 0.7–1 cm, yellow ripening to black; mesocarp thin, softening in hot water, flavor of avocado. Seed inedible. Collected more frequently in Borneo than in West Malaysia.

Clusiaceae

Garcinia. The vernacular name is kandis, unless otherwise noted. The fruit is a berry, with a thick pericarp bearing several flattened seeds in a pulpy mass. It is the pulp that is preferred, but the pericarp is edible in some species despite the presence of bitter yellow exudates.

Garcinia atroviridis T. Anders. / [*PFR 3024*] / **asam gelugor** / Fruit globose, about 7 cm across, with a broadly sunken apex, yellow; wall very thick, edible, sour; pulp pink, sweet. Cultivated in villages.

Garcinia bancana (Miq.) Miq. / [*PFR 3410*] / Fruit globose, 5 cm across, ripening orange-yellow; wall leathery; pulp white, sour.

Garcinia eugeniaefolia T. Anders. / [*LaFrankie 3347*] / Fruit globose, 2.5 cm across, ripening yellow; wall crisp, probably edible; pulp white, sweet. This species may be incorrectly identified; it closely matches the type specimen of *G. opaca* King var. *dumosa* Whitmore, which, in turn, should probably be named as a new species.

Garcinia forbesii King / [*LaFrankie 4031*] / Fruit globose to 8 cm across, ripening red; wall soft; pulp white, juicy and sweet.

Garcinia griffithii T. Anders. / [*PFR 1032*] / According to Whitmore (1972b), fruit globose, ribbed, 5–9 cm across, ripening yellow; wall thick, fleshy, edible but sour; pulp white, sour.

Garcinia malaccensis Hk. f. / [*LaFrankie 4113*] / **manggis hutan** / Fruit globose, to 4.5 cm across, maroon; wall hard; pulp white, sweet.

Garcinia nervosa Miq. / [*FRI 26151*] / Fruit globose, about 7 cm across, ripening yellowish pale yellow; wall soft and mealy; pulp yellow, fleshy, sour; flesh orange.

Garcinia nigrolineata T. Anders. / [*PFR 1050*] / Fruit globose with a short beak, faintly ribbed, 2.5–3.5 cm across, ripening orange-yellow; wall crisp; pulp scant.

Garcinia parvifolia (Miq.) Miq. / [*LaFrankie 2107*] / Fruit globose to ovoid, 1–3 cm long, ripening yellow; wall very thin, watery, acidic; pulp watery, white.

Garcinia prainiana King / [*PFR 3987*] / **cherupu, kechupu, menchupu** / Fruit globose with flattened apex, 2.5–4.5 cm across, ripening yellow; wall thin; pulp pale orange. Cultivated in villages.

Garcinia rostrata (Hassk.) Miq. / [*LaFrankie 3419*] / Fruit globose, less than 1.5 cm across, ripening yellow-green; wall woody; pulp scant.

Garcinia sp. nov. 1 / [*LaFrankie 2781*] / Fruit globose, about 5 cm across, ripening pale yellow; wall crisp; pulp pale white, firm, sour. This is probably a new species.

Garcinia sp. nov. 2 / [*LaFrankie 2985*] / Fruit not seen. This is probably a new species.

Euphorbiaceae

Baccaurea griffithii Hk. f. / [*PFR 1831*] / **tampoi** / Fruit globose, 5 cm across, orange to brown; wall dry, inedible; seed jacket white, sour. Sometimes gathered; elsewhere in Malaya gathered and sold in markets.

Baccaurea minor Hk. f. / [*PFR 2803*] / **tampoi** / Fruit ovoid to elongated, 12–17 mm long, orange; wall fleshy at first and edible; seed jacket orange, sour and bitter.

Baccaurea parviflora (M.A.) M.A. / [*LaFrankie 2025*] / **setambun tahi** / Fruit narrowly spindle-shaped, sharply angled, to 2.5 cm long, ripens red to purple-black; wall juicy, sour; seed jacket translucent white and very juicy and acidic.

Baccaurea pyriformis Gage / [*PFR 1833*] / **tampoi tunggan** / Fruit broadly 3-angled to pyriform, 2.5 cm long; wall thick and dry; seed jacket not known.

Baccaurea racemosa (Reinw.) M.A. / [*LaFrankie 3433*] / **setambun** / Fruit globose, about 18 mm across, brick-red; wall crisp, sour and edible when young; seed jacket blue, thin, very bitter.

Baccaurea reticulata Hk. f. / [*LaFrankie 2383*] / **tampoi** / Fruit globose, 3 cm across, dull brown; wall 4–5 mm thick, dry, inedible; seed jacket fleshy opaque white, sweet, pleasantly tart. Sometimes collected; elsewhere in Malaya gathered and sold in markets.

Elateriospermum tapos Bl. / [*PFR 3087*] / **perah** / Fruit a dry dehiscent capsule, oblong, 5–6 cm long, dull brown flushed pink, inedible. Seeds 3, about 4 cm × 2 cm, edible. Seeds are often gathered for roasting or boiling, but not often sold. Some races contain a heat labile poison, prussic acid (Corner 1988), but other races do not (Burkill 1935).

Phyllanthus emblica L. / [*PFR 3006*] / **pokok melaka** / Fruit a berry, globose, about 1.7 cm across, ripening greenish yellow; fruit wall firm, fleshy and juicy, sour. Cultivated in villages, more commonly in former times.

Fabaceae

Archidendron bulbalinum (Jack) Neilson / [*PFR 4294*] / **kerdas** / Fruit plump, 3.5–10 cm × 2.6 cm, green or dull red; wall thin, crisp, inedible. Seeds 2–5, about 1 cm long, flattened, pungent bitter flavor. Commonly gathered and sometimes sold in rural markets.

Dialium maingayi Baker / [*PFR 3892*] / **keranji tebal kecil** / Fruit ovoid, about 2 cm long, velvety brown; wall brittle when ripe. Seed squarish with a creamy edible aril. Occasionally gathered.

Dialium platysepalum Baker / [*PFR 4194*] / **keranji kuning besar** / Fruit ovoid, about 3 cm long, velvety brown; wall hard, not brittle when ripe; seed rounded with a creamy yellow aril. Sometimes gathered and sold in market (Burkill 1935).

Dialium procerum (van Steenis) Steyaert / [*PFR 4190*] / **keranji tunggal** / Fruit ovoid, slightly flattened, pointed, furrowed, about 4 cm × 2 cm, shiny black; wall hard. Seed oblong, flattened, with pulpy edible aril.

Dialium wallichianum Prain / [*PFR 6078*] / **keranji kuning kecil** / Fruit ovoid, about 2–2.5 cm long, velvety dark brown; wall hard, not brittle. Seed squarish with creamy edible aril.

Parkia speciosa Hassk. / [*PFR 4174*] / **petai** / Fruit oblong, flattened, twisted, constricted laterally between the seeds, 30–40 cm long, 4–5 cm wide, shiny green, ripening mauve-black; wall essentially inedible. Seeds 10–12, flattened, ellipsoid, 2–2.5 cm long, succulent, rather bitter, with pungent odor of garlic. Sometimes cultivated, but more commonly gathered from wild trees, and sold throughout the country in roadside markets.

Fagaceae

Castanopsis inermis (Wall.) Benth. & Hk. f. / [*PFR 6066*] / **berangan** / Cupule irregularly 4-valved, spineless, about 2 cm across. Seeds 1–3, triangular, pointed, with flat basal scar, brown; flesh white, crisp, fragrant, and flavorful when roasted. Seeds often collected and sometimes sold in rural markets.

Castanopsis megacarpa Gamble / [*LaFrankie 2022*] / **berangan babi** / Cupule oblong with densely crowded long spines, about 7 cm long. Seed 1, oblong, 4–5 cm long, brown; flesh white and oily. Burkill (1935) and Corner (1988) conflict on the edibility of this species, likely because the seed requires careful preparation through roasting or boiling.

Castanopsis schefferiana Hance / [*LaFrankie 4100*] / **berangan** / Cupule with short stout spines, 4-valved, 2.5–4 cm broad. Seeds 2–4, brown, flesh oily white, crisp. Not gathered in Pasoh, but according to Corner (1988) gathered in the north of Malaya.

Flacourtiaceae

Flacourtia rukam Zoll. & Mor. / [*LaFrankie 4030*] / **rukam** / Fruit a drupe, globose, about 2.5 cm across, ripening purplish green to dark red; pulp white, astringent, but bruising somehow renders the flesh sweet. Cultivated, but of minor value compared with *Flacourtia jangomas* (Lour.) Raemsch.

GNETACEAE

Gnetum gnemon L. var. *brunonianum* (Griff.) Miq. f. / [*LaFrankie 4256*] / **meninjau** / Seed ellipsoid, about 1 cm across, ripening orange-red or scarlet. Seeds edible after cooking. The variety *gnemon* is a larger tree and is widely cultivated. The seed is usually roasted and ground, used perhaps as much as a spice as a food.

MELIACEAE

Lansium domesticum Correa / [*LaFrankie 2766*] / **langsat, duku** / Fruit a berry, round or oblong, 2–5 cm across, ripening yellow; pericarp thin, dry; seed jacket pleasantly astringent to sweet. Widely cultivated in villages and plantations.

Reinwardiodendron cinereum (Hiern) Mabb. / [*FRI 21586*] / Fruit a berry, globose, 2 cm diam.; wall thin; aril white, sweet.

Sandoricum koetjape (Burm.f.) Merr. / [*PFR 3774*] / **sentul** / Fruit a berry, globose, 5–7.5 cm across, ripening yellow, thinly velvety; pericarp thin, dry; seed jacket white, juicy, sour or sweet.

MORACEAE

The fruit of *Artocarpus* is a synoecium; the seed and aril are edible in all of the following species. In some of the species the husk is inedible and must be broken away. In other species, called **tampang** in Malay, the entire fruit is edible.

Artocarpus anisophyllus Miq. / [*PFR 6097*] / **keledang babi** / Fruit, oblong, densely spiny, 10–12.5 cm × 7.5–10 cm, brown or olive-brown; husk inedible; pulp orange.

Artocarpus dadah Miq. / [*PFR 1475*] / **tampang bulu** / Fruit globose, velvety or smooth, 2.5–8.5 cm across, with deep pink flesh, edible as a whole. Frequent in villages, but perhaps not cultivated.

Artocarpus elasticus Bl. / [*PFR 3371*] / **terap nasi** / Fruit cylindric, with soft, recurved spines, about 11 cm × 5 cm, yellow-brown; husk inedible; pulp white, rancid odor.

Artocarpus fulvicortex Jarret / [*PFR 4215*] / **tampang gajah** / Fruit globose, velvety, 5–7 cm, ripening orange-yellow with yellow flesh, edible in its entirety.

Artocarpus integer (Thunb.) Merr. var. *sylvestris* Corner / [*Gentry 66897*] / **bangkong** / Fruit cylindric, muricate, up to 35 cm × 15 cm, yellow; the husk inedible; pulp slimy at maturity. The variety *integer* is extensively cultivated in villages and plantations. The wild variety is rarely collected, and then it is taken before mature and cooked.

Artocarpus lowii King / [*PFR 2851*] / **miku** / According to Corner (1988), fruit cylindric, covered by closely set, fleshy, conical warts, about 6.5 cm × 3.5 cm, yellow when ripe, edible in its entirety after excluding seeds. Occasional in villages.

Artocarpus maingayi King / [*PFR 1473*] / **pudu** / Fruit ellipsoid, about 4.5 cm × 2 cm, velvety, drying brown; wall and pulp not eaten.

Artocarpus nitidus Trec. / [*PFR 1478*] / **tampang** / According to Corner (1988), fruit rather flattened, 3–5 cm across, shiny, green turning orange, with bright pink flesh, edible in its entirety, but gummy.

Artocarpus rigidus Bl. / [*LaFrankie 2345*] / **temponek** / Fruit rounded, thickly set with stiff conical spines, about 15 cm across, greenish yellow ripening dull orange; husk thick and firm; pulp orange, of pleasant flavor.

Artocarpus scortechinii King / [*LaFrankie 4255*] / **terap hitam** / Fruit very similar to *A. elasticus*.

OXALIDACEAE

Sarcotheca griffithii (Hk.f.) Hall. f. / [*PFR 2280*] / **pupoi** / Fruit a fleshy berry, ellipsoid, bright green, to 3 cm long; flesh thick, juicy and pleasantly acid.

POLYGALACEAE

Xanthophyllum amoenum Chodat / [*PFR 4496*] / Fruit a berry, globose, to 3 cm across, pale green; pericarp thin, dry; pulp creamy, sweet. Possibly cultivated in Borneo.

Xanthophyllum stipitatum Benn. / [*PFR 1357*] / Fruit a berry, globose, to 4 cm across, mature fruit not seen. This species is closely related to *X. amoenum,* and the mature fruit may be edible in the same fashion. Rarely planted in villages.

Sapindaceae

The fruits of all the following species are drupes, more or less ellipsoid in shape, with essentially thin, dry walls and inedible seeds that bear a sweet fleshy sarcotesta.

Nephelium costatum Hiern. / [*FRI 27799*] / **sangal lotong** / Fruit 2.5–3.0 cm × 2 cm, yellow; pericarp densely set with soft flat spines; sarcotesta thin.

Nephelium cuspidatum Bl. var *eriopetalum* (Miq.) Leenh. / [*LaFrankie 3350*] / **lotong** / Fruit 5.5 cm × 3.5 cm, red; pericarp densely set with short soft spines; sarcotesta fairly thick, sour, tightly fixed to the seed. Cultivated. Rarely collected.

Nephelium cuspidatum Bl. var *ophiodes* (Radlk.) Leenh. / [*LaFrankie 2793*] / **sangal lotong** / Fruit 5.5 cm × 3.5 cm, dull red; pericarp densely set with soft spines; sarcotesta sour, tightly fixed to the seed. Rarely collected.

Nephelium hamulatum Radlk. / [*LaFrankie 4317*] / Fruit 3 × 2 cm, not seen mature; pericarp densely set with soft spines; sarcotesta thin.

Nephelium lappaceum L. var *pallens* (Hiern) Leenh. / [*LaFrankie 4125*] / **rambutan** / Fruit 5 cm × 3.5 cm, red; pericarp densely set with slender spines; sarcotesta thick and fleshy, sweet. The type variety of this species is the commonly cultivated rambutan; it is not known from the wild.

Nephelium maingayi Hiern / [*PFR 2417*] / **redan** / Fruit 2 cm × 1.6 cm, with a persistent style, pericarp smooth to slightly warty, ripening bright red; sarcotesta thin, sweet. Occasionally collected.

Pometia pinnata Forst. f. / [*PFR 4146*] / **kasai** / Fruit about 2 × 3 cm, purple; pericarp, smooth, thick, fleshy, inedible; sarcotesta thin, translucent white. Sometimes planted for its ornamental foliage, but not cultivated for its fruit.

Xerospermum noronhianum Bl. / [*LaFrankie 2334*] / **gigi buntal, rambutan pacat** / Fruit sub-globose, about 2 cm × 2.5 cm, wall muricate, ripening to bright yellow; sarcotesta bright yellow-orange, thin and very fragrant. Sometimes collected.

Sterculiaceae

Scaphium linearicarpum (Mast.) Pierre / [*PFR 4015*] / **kembang semangkok bulat** / Seeds about 2 cm diam. Commonly collected. See notes below.

Scaphium macropodum (Miq.) Heyne / [*PFR 2453*] / **kembang semangkok** / Seeds about 2 cm diam. Commonly collected. One seed placed in water can fill a cup with mucilage (bassorin, according to Burkill (1935)). Chiefly taken as a cooling tonic, and, therefore, more properly considered medicinal, but also sweetened and drunk as a refreshment.